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THE SCIENTIFIC MONTHLY

FEBRUARY, 1919

SCIENCE AND THE AFTER-WAR PERIOD¹

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BUREAU OF STANDARDS

SOMEWHAT more than a year ago it was my privilege to address the Philosophical Society of Washington on the subject, "Science and Warfare in France,"² in which I endeavored to indicate in some small measure the rôle science was playing in the war we all hope has just been brought to a close.

At this time may we not consider the transition period into which we are entering and ask ourselves what will be the effect of war on science, the men of science, and in the relations of science to the community and the state? What are some of the lessons this war has taught? And what plans have been made here and elsewhere to apply them?

A scientific man would hardly be so rash as to pose as a prophet, yet he may nevertheless try and assemble and pass in review some of the tendencies of the time; and it is only by an intelligent examination of the underlying changes which are being produced in science and in its relation to society that he is enabled to see his way ahead a little more clearly into the mist of the future; and he may thereby be enabled, at least in some small degree, to chart his course and take advantage of the various currents that have been set in motion by the war.

The question may here be asked, can we not see from previous wars what this war will bring forth, or at least the broad lines along which progress will be made, in science and in its relation to mankind? But with what previous war shall we compare this? Surely not with the short Franco-German war of 1870 in which but two nations were engaged; and if with the world-wide wars of the French revolution and Napoleon

¹ Address of the President of the Philosophical Society of Washington, January 4, 1919.

² SCIENTIFIC MONTHLY, October, 1917.

we have a duration of twenty-five years as compared with four; and if any war prior to that epoch is considered the development of science was hardly in a state to form a basis of comparison.

Again you may be asked, does war, did this war, stimulate scientific progress? Viewing the wealth of application of science in modern warfare, you will probably unhesitatingly say "Yes," but if you undertake to make a list of fundamental, new scientific principles developed as a war reaction I believe you will be embarrassed to name even a few of them, although there have been, of course, hundreds, nay, thousands, of applications of known scientific principles to new uses. It is still too soon, however, to estimate the scientific advance during the war and as caused by the war and such, even though I were competent, is not my purpose here. It will evidently be impossible to treat adequately the subject of "Science and the After-War Period" except in a most summary manner and I shall have to limit myself to certain phases in which I have been interested, paying particular attention to the physical sciences and the relation of science to industry.

What is the effect of the war on scientific production, is not an easy question to answer. Many men have been killed, including a few who are scientific producers, and many more young men who might have become distinguished in science; furthermore, not a few scientific centers have been destroyed. Thus viewed, there would appear to be a net loss to science in the world, but at the same time there have been stimulated to greater endeavor a considerable number of men of scientific ability and many new laboratories established. I believe that, for the United States, the effect of the war will not be detrimental to scientific production, as our losses in young men of scientific attainments have been relatively insignificant, and also I firmly trust the country has in part learned the lesson of the advantage to the nation of generously supporting research.

For a country such as France, which has borne the brunt of the fighting for four years, and not until after the first battle of the Marne was any effort made to conserve her scientific men, the matter appears to be much more serious; but who dares to predict that the United States, with nearly three times her population, will lead France as a producer of original ideas in science a generation hence? It is well to remember that many of the master minds in science of the nineteenth century were born during the Napoleonic wars, and that it is quality and not quantity that counts in scientific progress.

Finally one may ask, is the after-war period to be one of great scientific activity or one of relative quiet, and what will be the lines along which development will take place? This brings us to a consideration of the nature and permanence of war activities in science. Never before have science and scientific men been used to such an extent, both relatively and absolutely, as the servants of war both in the military establishments proper and in the not less important industrial supports. It is evident that what is beneficial in these relations should be maintained. In addition to the advancement in scientific knowledge, much of which is not yet generally available, brought into being by the war there has also been worked out for war purposes, in a more or less satisfactory way, schemes of cooperation of scientific men with each other, with the state, with industry and with the military. Some of these are transitory in character, others are serviceable for both peace and war, and some have been devised especially for the after-war period.

One might perhaps expect a certain relaxation of effort, even among scientific workers, following the strenuous efforts of the war, but one must not forget the natural zest of the scientific man to get back to his chosen field, which he will want to cultivate in his own way and not under the more or less arbitrarily imposed conditions of military requirements. Although much of the scientific work of the war has been done individually, probably by far the greater part has been by collective efforts of groups of workers usually under the guidance of some responsible committee or executive. Although this is no new phenomenon in scientific research, yet this cooperative method of attacking difficult problems has been, under the stress of war, developed to a hitherto unheard of degree. It is probable that the naturally individualistic traits of scientific men will tend to cause a lessening of this type of common endeavor, although in the distribution of investigation, between groups or individuals, there will probably be a greater number of groups than before the war, the habit of working together having been fostered, and its advantages appreciated in certain cases. For scientific research carried out in the interest of industry, this group method will very likely be greatly developed.

One of the fundamental factors of the greatest economic importance, which the exigencies of the war have brought repeatedly to the fore both in battle and in workshop, is what one might almost call the crusade of standardization. This has

taken on innumerable aspects and has constantly been recurring in conservation programs, economic production, and in the elimination of waste, time, materials and men. The savings that may be accomplished by the scientific application of what we may call the principles of standardization in production, manufacture and distribution of many, if not most, of the more usual commodities of commerce and industry is so great that I believe that it is not an exaggeration to say that by this means alone our national debt could soon be paid off both interest and principal. An indication of what can be done along this line has been ably demonstrated in our own country by the War Industries Board and in particular its Conservation Division working in cooperation with the various industries.

This cooperation between government and industry has been made most effective by the enforced revival of the guild organization in industry; the fact that an industry has been represented successfully as a whole during the war by an elected committee in treating with the government and among themselves on matters of common interest, is charged with great possibilities for like action along voluntary lines during peace times. Although of course many of the questions thus treated may be considered as outside the realms of science, nevertheless the scientific men can not be separated from this development which, it is most urgently desired, may be continued, although along less arbitrary lines than were necessary in time of war.

A closely related matter is that of preparing satisfactory specifications for materials and manufactured articles. Washington might almost have been called a specification factory during the past eighteen months. This is economically one of the most important of subjects, and too great emphasis can not be given to the desirability, not merely for materials of military interest, but for all uses, of being able to define adequately and sufficiently—not too loosely nor yet too rigorously—the materials and articles that form the basis for practically all purchases. There has been and still is in many fields great confusion, uncertainty and differences of opinion as to facts, and most of this is, in the last analysis, a direct result of ignorance of the scientific data regarding properties and materials on which the specifications are based. The nation has undoubtedly suffered untold losses on account of this ignorance, and endeavors should be made on a sufficiently comprehensive scale to eliminate as much as possible the waste arising from this cause.

Innumerable instances could be cited of the harmful and costly effects of too rigid specifications and of course we all know some of the dangers of too loosely drawn specifications. I will cite two of the former in my own field of metallurgy—a foreign government had a limitation, dating some thirty years back, of 0.05 per cent. copper in a certain grade of munition steel being made here. All the steel made from certain ores in this country necessarily carried four or five times the stipulated copper. Although at first insisting on the rejecting of the steel, the government in question finally accepted it after overwhelming evidence was submitted showing that ten times the amount of copper was not detrimental merely but of actual advantage in this steel. This single contract involved several millions of dollars; the total cost of all the experimental work ever done the world over on the effect of copper on steel would be at most a few thousands.

The second illustration is given by another government which desired to purchase steel here for aircraft parts with a phosphorus and sulphur content together of less than 0.03 per cent. They could buy no steel, and if they had been able to place an order it would have been at an exorbitant price. The fact that all the other allied countries were using a much less rigid specification with safety finally convinced them that theirs was too severe. Incidentally this latter case shows the evident advantages of interchange of ideas and experience in such matters.

Not a little of the delays in production of many materials for war purposes was due to the multiplicity of specifications insisted upon by the various independent purchasing departments of the government. Some progress is being made toward unity in standardization and specifications in the War Department and it is highly desirable that there be constituted a central body with authority for all departments. A single board, for example, to frame metal specifications for all would make for economy and efficiency.

That the technical public is now ready for such simplification and uniformity is evident by the recent creation, somewhat on the British model, of the Engineering Standards Committee. The Germans are also said to be forming a similar organization and the French and Italian governments have organized standards committees. It is to be hoped that this is one of the after-war activities to be pushed. It is not too much to say we have entered an era of standardization. It is not necessary before a group of scientific men, however it may be else-

where, to state that standardization necessarily involves research, often very elaborate and costly.

The relation of science to industry has been a fruitful subject for discussion in recent years, both here and abroad, and nowhere has the question of industrial research, as it is often called, been cultivated more intensively and made more progress as a direct result of the war than in Great Britain; and it may be of interest to mention briefly some of the steps in the progress.

Following the economic congress of the Allied Nations at Paris, there was formed in July, 1916, a committee presided over by Lord Burleigh on commercial and industrial policy after the war and the reports emanating from this body and its auxiliaries cover the whole field of the economic aspects—industrial, commercial, technical and scientific—of the after-war period, and lay particular emphasis, for example, on the protection and development of “key” or “pivotal” industries, most of them requiring the highest grade of scientific and technical skill for their maintenance and advancement, such as sympathetic drugs, optical glass, chemical glassware and porcelain, dye stuffs, magnetoos, high explosives, etc.

It is of interest to note in passing that the questions of decimal coinage and the compulsory use of the metric system of weights and measures were also considered and their adoption not advised. The arguments advanced for this conservative stand, if valid, are of a nature that would seem to make it difficult ever to make the metric system universal. A transition period like the present has precedent for the establishment of such a simplification of units and standards; for the metric system originated during the French Revolution and the International Bureau was founded at the time of the war of 1870.

There has since been established in England a Ministry of Reconstruction to deal with the numerous problems the transition period presents. A Department of Scientific and Industrial Research with a Parliamentary Secretary has also been created and has been active for nearly two years: (1) Encouraging firms in well-established industries to undertake cooperative study of the scientific problems affecting their processes and raw materials, and has at its disposal a sum of one million pounds for grants on the basis of an equal subscription from industry; (2) the department has further prepared to undertake at the public cost investigations of general interest; (3) the importance to industries of the establishment of standards

of a scientific basis is recognized and the financial control of the National Physical Laboratory has been taken over, with provisions for pensioning the staff; (4) efforts are being made to increase the numbers of trained research workers which had reached a dangerously low ebb in 1915, as recognized by Lord Burleigh's committee, who found but forty qualified unattached persons available for research in the United Kingdom.

Very substantial results have already been achieved in these several fields and hardly a copy of *Nature* can now appear which does not record some new grant, technical committee, industrial research association or other advance in the interdependence of science and industry under governmental supervision. It is also especially significant to note that some of the industries are also standing on their own feet and establishing their own research laboratories along cooperative lines.

There is also the recently founded British Science Guild with a distinguished membership, which maintains lectureships and does much to foster the dissemination of the aims of research among the public.

This spirit of organized research has been contagious throughout the British Empire and there are being established similar associations, institutes and laboratories in Canada, Australia, South Africa and elsewhere.

Rather curiously enough in the democratic British communities, it is the government that appears to be taking the lead in the stimulation of scientific research, particularly in its relation to industry. It is probable that the reasons for governmental initiative are in part a result of the abnormal conditions of the nation at war, during which time individual efforts are much more difficult of effective expression—the community in the time of danger is thinking and acting as a unit under military stress and military methods predominate. As normal times return we may expect the state to relax its vigilance and the individual person, society or industry to reassert to a greater degree their qualities of initiative and independence. It is not improbable, however, that there is a genuine, conscious effort for the more generous support of research by the British public as a national asset, which support will be maintained in peace times on a much more extensive scale than in pre-war times.

Another incident significant of the trend of the times is the formation in October last of The British National Union for Scientific Workers with five hundred members, whose main objects, most worthy of repeating here, are: (1) to advance

the interest of science as an essential element of the national life, (2) to regulate the conditions of employment of persons of adequate scientific training and knowledge, (3) to secure in the interests of national efficiency that all scientific and technical departments in the public service, and all industrial posts involving scientific knowledge, shall be under the direct control of persons having adequate scientific training and knowledge.

The question that every scientific man in America naturally and perhaps unconsciously asks himself on hearing of such an organization is, of course, why not form such a union here? Indeed, the matter has been discussed in some centers and it would probably not be difficult to organize in the United States a similar union of scientific workers. Bodies somewhat similar already exist among various educational and professional groups. It should be borne in mind, however, in considering this matter that in addition to the general objects stated above, the scientific workers of England were almost compelled to organize in order to have representation on the so-called Whitley Industrial Councils, having to do with matters affecting labor and management relations in industry, and one of the creations of the reconstruction program.

Forming what is perhaps the natural corollary to the foregoing, there has been some serious discussion in Britain of the desirability of having representatives of science as such in Parliament; certain of the universities have had representation for a long time, but it is doubtful if the matter of representatives of science is pushed seriously. If science, why not literature, the arts and so on?

While we are considering the question of the scientific man himself, there is one phase of his relation to science and to industry that I can not pass by, which will need perhaps even more serious consideration in this transition period than it has had in the past. I refer to the bidding for his services by technical industries. A man who leaves the university or professional school and enters the research department of an industrial concern is not the man I mean. Is not the case different for a man who has chosen his career of scientific investigation in a university or other scientific institution independent of or under state control? This man, if taken from his environment by offers of financial gain, goes to enrich most certainly some special interest with his science and is still a valuable member of the community; but generally speaking, is it not of advantage to the community to keep that man contented in

his, what I am tempted to call, more natural environment? Natural, for he chose it and adapted himself to it. When the staff of an institution like the Geophysical Laboratory, to cite a most striking example, is largely absorbed by industry, does not the matter become of serious concern? Should not the industries rather be encouraged to take their scientific men when they are young and not break up growing scientific concerns? No doubt a certain amount of interchange in scientific personnel is to be encouraged, but it should be interchange and not bleeding practised by industry. Providing an adequate supply of scientifically trained men for the needs of industry and defining the proper relations between industrial management and scientific centers are questions meriting the most serious concern of the community. Our supply of scientifically and technically trained men is all too meager and if, as many expect, there is now to be a period of expansion in the foreign trade of the United States involving possibly the establishment abroad of numerous branches of highly technical industries, the demand for such men will become more urgent than ever, particularly with men of scientific training with engineering experience.

This brings us to the question of the education of scientific men, which subject it is possible to mention but briefly. Here again the interruption, disorganization and readjustment of educational training in America have been insignificant as compared with the disturbances in education brought about by the necessities of war of the European countries, but even in this country experiments with intensive training and shortened courses have been tried on a large scale, but, it must be borne in mind, for a limited period only. Our educational institutions will undoubtedly be able to preserve some of the beneficial characteristics brought out by such speeding up, but for the most part there probably will be little effect on the kind of training our scientific men will get.

It would appear to be highly desirable that as large a proportion as heretofore of our scientific men pass a portion of their preparative period abroad amid cultural surroundings different from those in which they grew up. As a beginning it is to be hoped that many of our young men now in France will be given the opportunity to take advantage of the generous offer of the French Government for instruction in the schools and universities of France. This, if carried out on a considerable scale, will have far-reaching effects, the benefits of which can hardly be overestimated. It is also to be hoped

our universities will not only encourage the coming of foreigners more than heretofore, but also render easier the migration of American students from one American institution to another. The establishment in Washington of schools framed on lines similar to the *Ecole des Hautes Etudes* and the *Collège de France*, which are devoted exclusively to research, would go far toward making more generally available the research facilities and scientific men of the capital.

During the war the scientific men of the country have been thrown into close association with each other, perhaps even closer in many instances than in pre-war times in spite of the decrease of attendance at scientific meetings and in the number of such meetings; in addition, there has been developed, as never before, acquaintance and cooperation of the men of science of this and the allied countries; and not only the men of one science have been thrown together but representatives of what we ordinarily consider very diverse sciences have been brought into close personal and professional contact. All this makes for the unity of science and the broadening of scientific men. It would seem desirable to make an effort to perpetuate this habit of association of scientific men from different countries. You will recall that in 1914 there were projected several international congresses in science and engineering. Would it not be well, as soon as circumstances permit, at least to revive these projected congresses with such limitations as comply with the conclusions reached recently in London by representatives of the national academies of the Inter-Allied Nations?

A very important matter that has been held generally in abeyance by the war and which will soon again require the serious attention of scientific gatherings is that of the policies regarding scientific publications. Very definite proposals have been discussed recently in England looking particularly to the avoidance of duplication, confusion and other anomalies in scientific literature and to its more effective distribution. This question again is a variant of the standardization problem and is further complicated by interests or prejudices, both national and professional, of numerous societies representing often if not competing, yet overlapping fields of science. For any particular branch of science, there are also the international aspects to be considered, including the question of language; and it is within the bounds of possibility, for example, that there will occur a revival of the more concerted efforts for the use of an auxiliary international language such as Esperanto,

or if you will a standardized, international form of expression in science.

If I have dwelt with less emphasis on some of the recent, strictly American tendencies of scientific development, I trust it fair to assume you are acquainted with most of them. The great work of the National Research Council is certainly familiar to us all and it is good news to hear that plans are being developed toward reorganizing the Council to meet the conditions of the reconstruction period. There is great need in the United States, with our relative geographical isolation and great distances between many scientific centers, for an active, scientific body devoted to the initiation, stimulation and correlation of scientific research.

Furthermore, by emphasizing the recent British developments in the relations of state, industry and science, I by no means desire to imply that we have not been active in America. These matters are being freely discussed here and many plans are being formulated and some are in operation, for cooperative research in various branches of science, particularly as applied to industry. The weekly and monthly scientific press are full of them. It is to be noted that in contrast with the British experience, in America less expectation is being placed on governmental aid to new research projects; an exception to this is of course the Smith-Howard bill now before Congress for promoting engineering research in the several states.

In America, individual initiative in the past has on the whole been more potent than the state in providing the funds for maintaining research. In the prosecution of the war now drawing to a close, however, the federal government has spent huge sums on projects requiring scientific investigation and development, and in order to carry out the scientific projects of military urgency, has mobilized the scientific men of the country. Is it well during the after-war period to demobilize completely this army of scientific men? No one would yet think of having no organized military force in peace time, and there is in every well-organized state always at least a skeleton army with all branches represented, including a competent staff, arsenals, depots, surplus munitions and supplies.

The great scientific bureaus of the government are organized for the problems of peace and, although they can give a good account of themselves under war conditions, yet would it not be well, at least until the millennium is more clearly in sight, to retain more than a nucleus of an organization of scientific men in the service of the state and especially in the mili-

tary and naval establishments? We can all name branch after branch of each of these services which before the war contained almost no scientific personnel but to which have been added during the war scores and hundreds of scientific men; and in some cases it was no easy matter to gather and coordinate this personnel.

What, therefore, appears to me as one of the very important problems of the transition period, namely, the proper balancing and distribution of the scientific forces of the country as between the military and civilian activities of the state on the one hand, and the industrial and academic activities of the country on the other, is even now undergoing the process of being solved. The readjustment will go on largely unperceived at the moment and the changes will be accompanied by the usual quiet but significant struggles. The more rapidly the world settles down to more stable conditions, the more promptly shall we reach this dynamic equilibrium of the distribution of scientific men and the balancing of competing fields in scientific research.